LArSoft Simulations Kickoff Meeting

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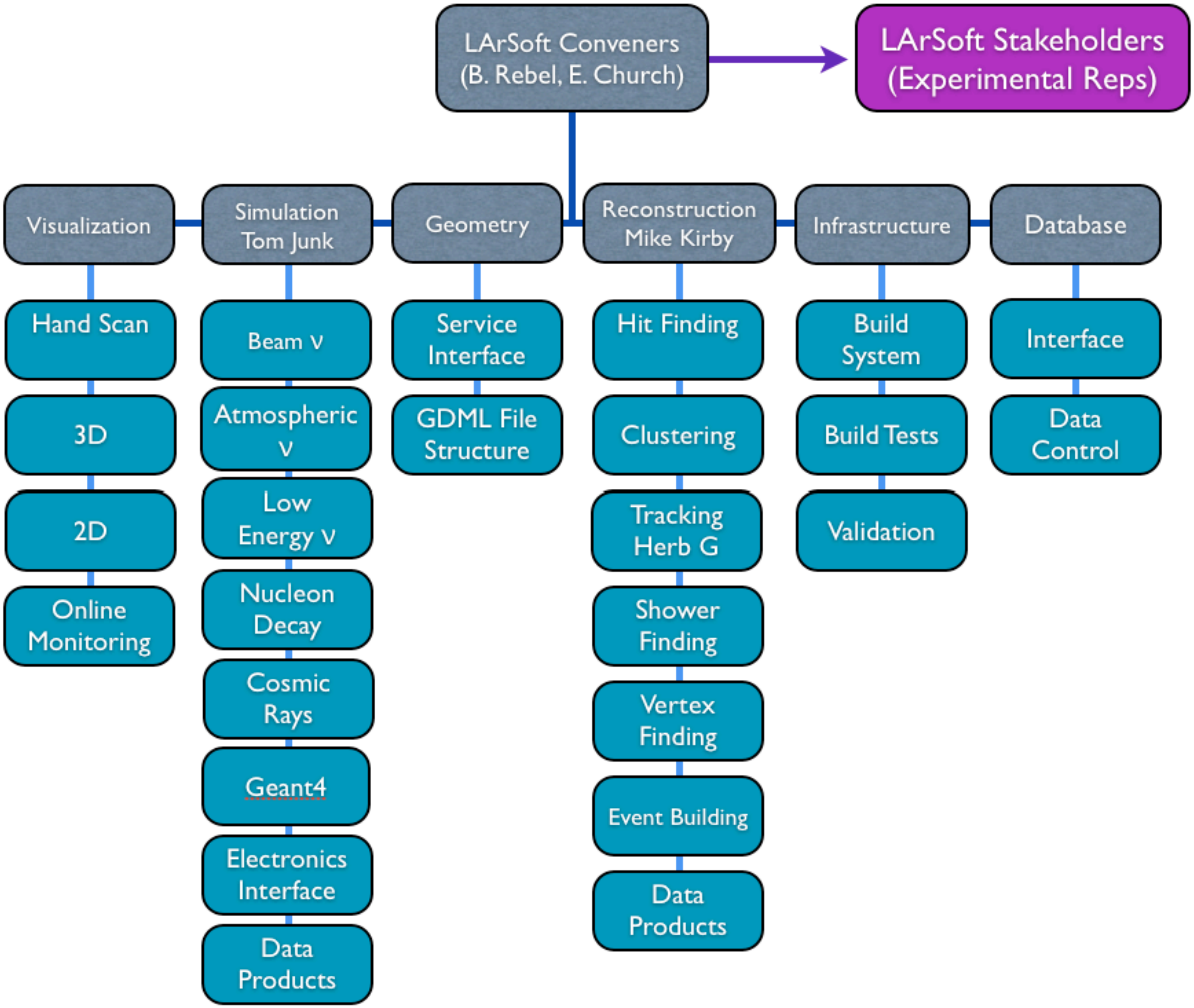
- Task Categories
- Relationship to Other Groups
- People


LArSoft Conveners
(B. Rebel, E. Church)
LArSoft Stakeholders
(Experimental Reps)
Visualization
Simulation
Tom Junk
Geometry
Reconstruction
Mike Kirby
Infrastructure
Database
Hand Scan
3D
2D
Online Monitoring
Beam ν
Atmospheric ν
Low Energy ν
Nucleon Decay
Cosmic Rays
Geant4
Electronics Interface
Data Products
Service Interface
GDML File Structure
Hit Finding
Clustering
Tracking
Herb G
Shower Finding
Vertex Finding
Event Building
Data Products
Build System
Build Tests
Validation
Interface
Data Control

Task Categories

Neutrino beam simulations

- Flux format
  - Histograms and Ntuples
- Maintenance
  - Seems that they go in /grid/fermiapp/lbne/lar/aux/ Did not immediately find Mary's DocDB 2511 files in there. How to specify this directory in .fcl? Code?
  - Beam Redesigns / value engineering
  - Systematic uncertainties, time dependence
    - alternate shape files
  - ND constraints – what if we learn our beam is not exactly as predicted? Re-simulate, or just re-weight events? Propagation of weights through generation, simulation, reconstruction, and analysis chains
  - Need to keep this updated
- Large Samples – responsibility of experiment collaborations

These tasks may be in the purview of a more general Neutrino Simulations group; Our job is to supply what we know, share our knowledge, and integrate the work that is done outside of here.

Atmospheric Neutrino Simulations

- Generated with GENIE (other generators?) like the beam simulations
- Important to use the same generator, simulation, and reconstruction tools for atmospheric and beam events because they are control samples for each other – can be used to calibrate/validate/measure efficiencies, mis-ID rates, etc. in situ.
- Already have samples of atmospheric neutrinos generated using Jeff de Jong's atmospheric flux calculations at SURF's 800 ft level. 4850? Surface?
- Other experiments and geometries

Looks as if the LArSoft area has beam flux files for several different beams; perhaps we should collect Atmospheric Neutrino flux information as well, or leave it up to the collaborations?

Cosmic Ray Simulations

- Another important control sample/background for physics
- CRY generator (Los Alamos) – any others?
- Still need also fluxes – highly anisotropic. Maybe ntuples are easy to define

Low-Energy Neutrino Events

- I know less about these – See M. Vagins talk at the March Collaboration meeting.
- Good for supernova burst physics, relic supernova studies, solar, and geo-neutrino studies
- Could be difficult, but we should support the simulation effort
- GENIE appropriate at low energies?

Nucleon Decay

p DECAY MODES	Partial mean life (10^{30} years)	Confidence level	p (MeV/c)
Antilepton + meson			
$N \to e^+\pi$	> 158 (n), > 8200 (p)	90%	459
$N \to \mu^+\pi$	> 100 (n), > 6600 (p)	90%	453
$N \to \nu\pi$	> 112 (n), > 25 (p)	90%	459
$p \to e^+\eta$	> 313	90%	309
$p \to \mu^+\eta$	> 126	90%	297
$n \to \nu\eta$	> 158	90%	310
$N \to e^+\rho$	> 217 (n), > 75 (p)	90%	149
$N \to \mu^+\rho$	> 228 (n), > 110 (p)	90%	113
$N \to \nu\rho$	> 19 (n), > 162 (p)	90%	149
$p \to e^+\omega$	> 107	90%	143
$p \to \mu^+\omega$	> 117	90%	105
$n \to \nu\omega$	> 108	90%	144
$N \to e^+K$	> 17 (n), > 150 (p)	90%	339
$p \to e^+K^0_S$	> 120	90%	337
$p \to e^+K^0_L$	> 51	90%	337
$N \to \mu^+K$	> 26 (n), > 120 (p)	90%	329
$p \to \mu^+K^0_S$	> 150	90%	326
$p \to \mu^+K^0_L$	> 83	90%	326
$N \to \nu K$	> 86 (n), > 670 (p)	90%	339
$n \to \nu K^0_S$	> 51	90%	338
$p \to e^+K^*(892)^0$	> 84	90%	45
$N \to \nu K^*(892)$	> 78 (n), > 51 (p)	90%	45
Antilepton + mesons			
$p \to e^+\pi^+\pi^-$	> 82	90%	448
$p \to e^+\pi^0\pi^0$	> 147	90%	449
$n \to e^+\pi^-\pi^0$	> 52	90%	449
$p \to \mu^+\pi^+\pi^-$	> 133	90%	425
$p \to \mu^+\pi^0\pi^0$	> 101	90%	427
$n \to \mu^+\pi^-\pi^0$	> 74	90%	427
$n \to e^+K^0\pi^-$	> 18	90%	319

Rich subject! Event generation is naively simple, but we need nuclear scattering models for FSR with the Ar nuclei

Lepton + meson			
$n \to e^-\pi^+$	> 65	90%	459
$n \to \mu^-\pi^+$	> 49	90%	453
$n \to e^-\rho^+$	> 62	90%	150
$n \to \mu^-\rho^+$	> 7	90%	114
$n \to e^-K^+$	> 32	90%	340
$n \to \mu^-K^+$	> 57	90%	330
Lepton + mesons			
$p \to e^-\pi^+\pi^+$	> 30	90%	448
$n \to e^-\pi^+\pi^0$	> 29	90%	449
$p \to \mu^-\pi^+\pi^+$	> 17	90%	425
$n \to \mu^-\pi^+\pi^0$	> 34	90%	427
$p \to e^-\pi^+K^+$	> 75	90%	320
$p \to \mu^-\pi^+K^+$	> 245	90%	279
Antilepton + photon(s)			
$p \to e^+\gamma$	> 670	90%	469
$p \to \mu^+\gamma$	> 478	90%	463
$n \to \nu\gamma$	> 28	90%	470
$p \to e^+\gamma\gamma$	> 100	90%	469
$n \to \nu\gamma\gamma$	> 219	90%	470

A Simulation Issue Which Always Needs to be Addressed

Event Overlay / Track Embedding

Used in Water Cherenkov to test pizero reconstruction where at least one electromagnetic shower is known to be one, and one is a data object

Track embedding used in tracking chamber reconstruction calibration and validation tools to estimate tracking efficiency in a data-based way.

What to do when we need to add additional elements to the simulation, either from real data or from MC.

Only one input source? Overlaying two events may require two input sources and one output source.

My run of the examples on the Wiki

It's really easy to run! Just a few minutes to copy .fcl files, edit input/output names, and run 10 events. prodgenie.fcl example runs Argoneut

flux file:

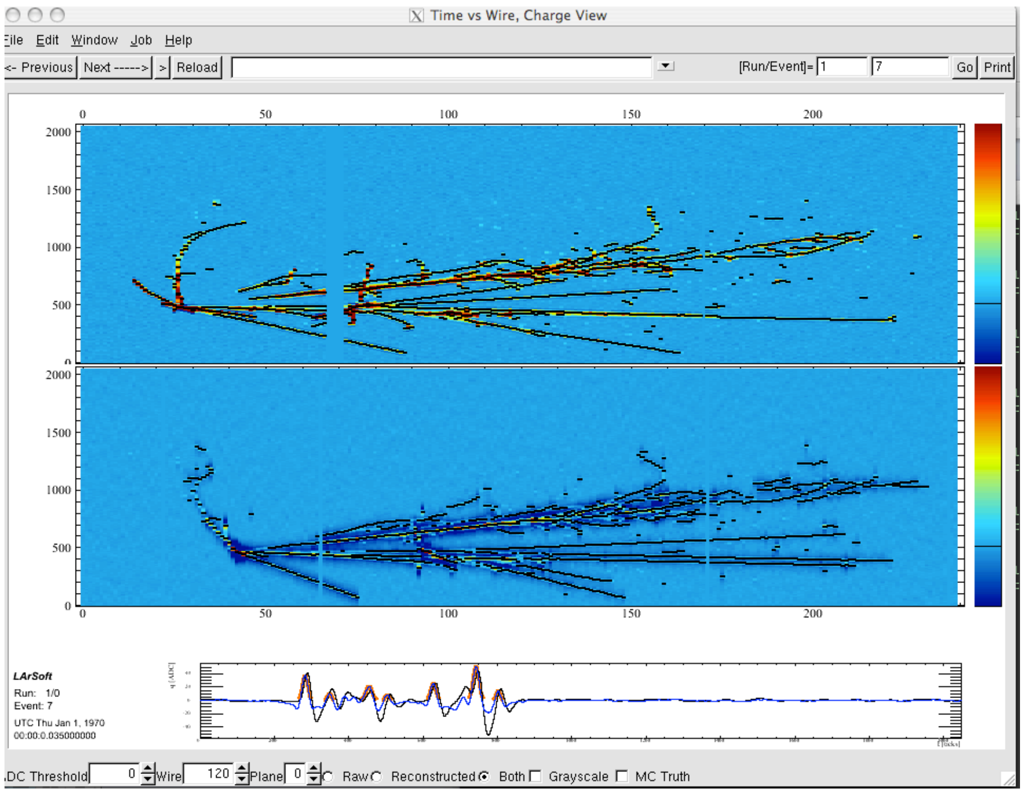
/grid/fermiapp/lbne/lar/aux/argoneut/gsimple_ArgoNeuT_le010z185i_run3_38l0-9r_00001.root

from job/genie.fcl running the argoneut_genie_simple generator

Simulated output: 6.2 Mb in size

Run standard_reco.fcl

Reco output: 78 Mb



Simulation Issues

- GEANT4
  - Physics lists
  - Version control   (CDF uses GEANT3!)
  - Early development – follow along with G4 development. Physics production stage – we'll probably have to freeze the G4 version
  - Interact with the G4 developers if we see problems (arose with WC several times/year – but that was with optical photon modeling which G4 was still not all that good at) -- Mie scattering had to be added, and a problem with indexing touchable objects. We might run into similar problems.
  - Interface with R. Hatcher's efforts – share G4 experience

- Electronics Simulation
  - Already have a parameterization of wire responses
  - Validation with data – tuning
  - Separating effects of electronics and Argon purity
  - Noise
  - Introduction of new active detectors
    - Light collectors
    - Veto (depends on detector configuration)
    - Tracking chambers
    - Magnetic field
  - Trigger modeling

Experiment-specific, but we should make LArSoft friendly to extensions to non-LAr sensitive detector components

Systematic Uncertainties

- Beam Flux assumptions
- Nuclear cross sections
- GENIE FSI/nuclear effects
- Detector response
  - Charge Collection Efficiency
  - Light Collection Efficiency
  - Timing resolution and offsets
  - Noise
  - Trigger Modeling
  - Veto efficiency
  - Efficiency of correlating with other detectors
- Reconstruction efficiency
- Shapes of distributions cut on and used as inputs to MVA's efficiencies and MisID
- Background modeling
  - cosmics
  - atmospheric neutrinos)
  - rock events (cosmic, atmospheric, and beam)
- Magnetic field

MC is (and should be) "too good" Resolution and efficiencies too high.
-- Easier to smear, drop hits than to unsmear, add hits
Are smearing/hit deletion/ noise addition tools generic enough to do here or are they experiment-specific?

A "fast" simulation for estimating systematics?

Would like to explore as many of these as we can by reweighting/smearing events
-- reduces stat. uncertainty

Data Products

- Maintenance of output format of simulation (reconstruction is another group)
- Simulated wire charges, MC truth, Event weights,
  photon timing and collected charge in PMT's (if we have them)
  Detector geometry – WCSim coupled that with the simulated output by
  putting a representation of the geometry in the simulated data files
- Summary histograms
- Validation suite – also to be run online and compared with simulation
- Backwards compatibility
- Interface to mass storage (SAM, Globus tools)
- Random number generator configuration and seeds (plus a few numbers for tests?)
- Would like ability to re-simulate the same input file or in case it is lost, the simulated output file has all the information to rerun the simulation

- Metadata
  - MC configuration information
    - Physics Lists
    - Flux parameterization at the detector site
    - Generator Name and Generator Version
    - G4 Version
    - Detector response model version
    - Detector parameters – charge collection efficiency
  - Allow after-the-fact editing in case bugs are found
  - Logfiles
  - Searchable web interface for MC samples (database?)

Relationships with Other Groups

- Robert Hatcher's general neutrino simulations effort
  - Most physics things we can and should share.
  - GEANT4 and GENIE and other generators are common to us all
  - Some systematics are shared, but possibly many aren't and are instead detector specific.
  - This effort is somewhat in-between – argon-specific issues fall here
- Martin Tzanov's nuclear cross sections group
  - Has wide-ranging applicability – everyone needs this
  - Within the LBNE collaboration, but we should share what comes from that group with other argon and other neutrino experiments
- Detector Simulation Groups
  - Some needs are common, but many are specific to a collaboration's efforts.
    - Additional detectors – light collectors?
    - Argon Detector is used in tandem with another detector (ArgoNeut)

- Other Argon efforts worldwide – ICARUS, GLACIER